UNIVERSITI PUTRA MALAYSIA

GEOSPATIAL ANALYSIS FOR DETECTION OF SINKHOLE DISTRIBUTION AND CHANGE IN KINTA VALLEY, MALAYSIA

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GEOSPATIAL ANALYSIS FOR DETECTION OF SINKHOLE DISTRIBUTION AND CHANGE IN KINTA VALLEY, MALAYSIA

By

OMAR MAHMOUD SULEIMAN ALKOURI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Doctor of Philosophy

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DEDICATION

This work is dedicated to my family members and my Wife who are always giving me encouragement and support

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

GEOSPATIAL ANALYSIS FOR DETECTION OF SINKHOLE DISTRIBUTION AND CHANGE IN KINTA VALLEY, MALAYSIA

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February 2009

Chairman: Associate Professor Husaini Omar, PhD

Faculty : Engineering

The geospatial study of Karst over 25 years uncontrolled use and the resulting environmental impact in Kinta Valley area-Malaysia is described. The geo-hazard map for sinkholes distribution was developed and the changes of limestone topography were analyzed as well as the relative importance of geological and geo-morphological factors. Due to intensification of human activities the Karst has suffered several environmentally relevant changes. An assessment of the degree of hazard was conducted by utilizing 10 m^2 cell dimension. The results showed that the land use in terms of urbanization and industrialization has a direct influence on the Karst features development. The geo-hazard map indicated that 93 % of sinkholes occurrence were located in the high and very high potential hazard areas in contrast to the areas in the middle and southwest of the Kinta valley. The highest sinkhole occurrence was recorded in January 2005 which was attributed to the earthquake on 26th December, 2004. The sinkhole formation was further aggravated by heavy rainfall and surface mining. Fortunately, our spatial temporal data model facilitated the delineation of the changes in Karst topography. A geo-statistical investigation was carried out on the nature of topographic variation and its roughness to ascertain the nature of Karst and its distinctiveness from non-Karst landscapes. Bukit Merah village was preferentially selected for a case study. The condition of the mining site from 1991 to 2007 was revealed by False color composites of land-observing satellites the Thematic Mapper and Satellite Pour l'Observation de la Terre, the mining activities at the site increased by 383 % over the study period. The area of the water body increased progressively from 0.972 km^2 in 1991 to 3.726 km^2 in 2007. Given the current degradation scenario of the limestone resources in Kinta Valley and associated environmental impacts, the study emphasizes the need for conservation of these valuable resources.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

ANALISIS GEOSPATIAL BAGI PENGESANAN TABURAN DAN PERUBAHAN LUBANG-TENGGELAM DI LEMBAH KINTA, MALAYSIA

Oleh

OMAR MAHMOUD SULEIMAN ALKOURI

Februari 2009

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Suatu kajian geospatial Karst merangkumi 25 tahun penggunaan tanah tidak terkawal dan kesannya terhadap persekitaran di Lembah Kinta di Malaysia dihuraikan di sini. Peta geo-hazard bagi taburan lubang tenggelam telah dikembangkan dan perubahan topografi batukapur juga telah dianalisa, selain daripada kepentingan relatif faktor-faktor geologi dan geomorfologi. Oleh kerana peningkatan kegiatan manusia, Karst telah mengalami beberapa perubahan yang relevan terhadap persekitaran. Suatu penilaian darjah bahaya telah dijalankan menggunakan sel berdimensi 10 m^2. Hasil penyelidikan menunjukkan bahawa penggunaan tanah dari segi urbanisasi dan pengindustrian mempunyai kesan secara langsung terhadap ciri-ciri pembangunan Karst. Peta geo-hazard menunjukkan bahawa 93% kejadian lubang tenggelam berlaku di kawasan berpotensi hazard yang tinggi dan sangat tinggi berbanding di tengah dan di Barat Daya lembah Kinta. Kejadian lubang tenggelam yang tertinggi dicatat pada bulan Januari 2005 yang diakibatkan gempa bumi pada 26 Disember 2004. Kejadian lubang tenggelam ini diburukkan lagi oleh hujan yang lebat dan perlombongan permukaan. Mujurnya,

model data spatial-temporal kami telah mempermudahkan penentuan perubahan pada topografi Karst. Suatu kajian geo-satistikal telah dijalankan ke atas sifat perbezaan topografi dan kakasarannya untuk menentukan sifat-sifat Karst dan perbezaannya berbanding mukabumi bukan Karst. Kampung Bukit Merah telah dipilih khusus untuk kajian kes. Keadaan tapak perlombongan dari tahun 1991 hingga 2007 telah ditunjukkan oleh imej komposit false-colour daripada satelit-satelit kajibumi Thematic Mapper dan Satellite Pour l'Observation de la Terre. Kegiatan perlombongan di tapak tersebut bertambah sebanyak 383% sepanjang tempoh kajian tersebut. Luas k awasan air kian bertambah dari 0.972 km^2 pada tahun 1991 kepada 3.726 km^2 pada tahun 2007. Dengan ternyatanya senario pemburukan sumber-sumber batukapur di Lembah Kinta serta kesannya terhadap persekitaran, kajian ini menggariskan perlunya pemuliharaan sumber-sumber yang bernilai ini.

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APPROVAL SHEET

I certify that an Examination Committee has met on 23 February 2009 to conduct the final examination of Omar Mahmoud Suleiman Alkouri on his Doctor of Philosophy thesis entitled "Geospatial Analysis for Sinkholes Change Detection in Kinta Valley, Malaysia" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the student be awarded the degree of Doctor of Philosophy.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as partial fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except that for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions

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OMAR MAHMOUD AL-KOURI

Date:

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LIST OF ABBREVIATIONS

GIS	Geographic Information System
KLLF	Kuala Lumpur Limestone Formation
MMCB	Malaysia Mining Corporation Berhad
VSMSTDM	Volumetric Surface Movement Spatiotemporal Data Model
RSO	Rectified Skew Orthomorphic
ESRI	Environmental Systems Research Institute
GPS	Global Positioning System
UTM	Universal Transverse Mercator
DTM	Digital Terrain Models
TIN	Triangulation Irregular Network
NST	New Straits Times
FCC	False Colour Composites
RTD	Rancangan Tempatan Daerah (Location Planning Area)
MSL	Mean Sea Level
Mm	Magnitude Moment
MACRES	Malaysian Centre for Remote Sensing
CaCO3	Calcium Carbonate
MgCO3	Magnesium Carbonate

CHAPTER 1

INTRODUCTION

1.1 Background

Sinkholes, the most common and most easily recognized surface features of Karst topography, are defined as or generally refer to an area of localized land surface subsidence or collapse, due to Karst processes, which result in a closed hollow of moderated dimensions (Beck, 1984). The term "karst" refers to a type of terrain, known for its distinctive topography in which the landscape is largely shaped by the dissolving action of meteoric water on carbonate bedrock. (Alexandar, 2000, and Smith, 1996) The late twentieth century has witnessed a substantial increase in natural disasters and awareness of environmental hazard. Gao and Alexander (2008) mentioned that, the influences of sinkhole formation and the ability to accurately predict sinkhole hazards is critical to environmental management efforts in the karst area. The karst landforms of tropical regions, such as those found in Peninsular Malaysia, are distinguishable by their mountains with steep slopes separated by broad flat valleys or plains. These tower-like mountains with rocky overhanging cliffs are riddled with caves and are only found in humid-tropical limestone regions (Fatihah, 2003).

Karst in the Kinta Valley takes the form of a typical tropical karst. It was renowned as the world's richest tin mining area in the early 60's and 70's (Fatihah, 2003). Since then, the heavy consumption of this mineral resource in tandem with rapid development and urbanization has tremendous impacts on the limestone karst especially in the absence of any plans and management practices to preserve it. Mining activities prevailed in most of the karst's history, while land developers were also unaware of the karst value and its essence in the ecological system. In addition local settlers were also looking for wealth and higher standard of living. All these factors had essentially ignored the significance of the karst as a distinctive feature of its own in the Kinta surroundings. Poor management plans were implemented in the early seventies but were neither enough nor effective since the techniques employed were traditional, costly, time-consuming and lacking enforcement.

Geohazard (geological hazard) is a naturally occurring or man-made geologic condition or phenomenon that presents a potential hazard or is a potential danger to life or property (American Geological Institute, 1984). Kovach (1995) and Smith (1996) reported that hazard is a source of danger and its evaluation encompasses three elements - potential hazard of personal harm (death, injury, disease, stress), potential hazard of property (property damage, economic loss) and potential hazard of environmental damage (loss of flora fauna, pollution, and loss of amenity); Geohazard is therefore a disastrous and unavoidable element of life.

Sinkholes, the crux of the geohazard issue in the Kinta Limestone Formation, are due to chemical weathering of the limestone bedrock, which gives rise to cavities and subsequently sinkholes. The formation or emergence of sinkhole is usually very sudden and unpredictable, and its development can be catastrophic.

Many environmental problems can be predicted; especially when geohazards are analyzed using technological advanced tools such as the Geographical Information Systems (GIS). Hazard evaluation requires answering some questions such as; what is hazard? Where is it going to occur? What will be its impact? How widespread is it, or the potential of its spread? Can it be avoided? And if not, what can be done to reduce the effect of hazard? Early identification of geohazards means that potential potential hazards can be avoided or mitigated, often without additional cost, and is vital to the success of development planning and its implementation (Abu Shariah, 2002). GIS enables researchers to objectively identify the triggering factors of karst hazards and store them in a spatial database. (Harrison., 2004). Spatial information technology is useful in dealing with natural hazards as it strengthens coordination among multiple programs of potential hazard management through tools for identification, analyses, assessment, treatment and monitoring (Mansor et al., 2004).

One great challenge resides on quantifying the nature and evaluating sinkhole related geo-hazards from space, which would lead to a better understanding of the terrain. Fortunately, modern technology allows more complex analysis of data, which can also be more efficiently collected in the field. From high-resolution stereo pair's images, Digital Terrain Models (DTM) can be generated and this enables detail analysis of the terrain with more sophisticated tools.

Currently Spatiotemporal Data Model lacks the understanding of the real world phenomena. In the near future, Spatiotemporal Data Model will become a very crucial factor in developing real-time processes in the GIS (Rahim et al., 2005). The